translation by Chappellier,[31] and also the recent works by Baur,[32] Haecker,[33] and Goldschmidt,[34] will be found very useful to the general student of Mendelism.

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THE RANGE OF SIZE IN THE VERTEBRATES

A SMALL shrew, *Microsorex winnemana,* recently described from Virginia by Preble, is said, if conclusions from but two specimens may be drawn, to be the smallest species of shrew and therefore the smallest mammal yet known from America.[1] These specimens measured 78 and 86 mm., respectively, in total length. *Microsorex hoyi* (Baird) of the eastern and central states averages from 82 to 88 mm. and *Sorex fontinalis* Hollister and *Sorex personatus* Geoffroy are but slightly larger. *Blarina parva* (Say) a short-tailed shrew, averaging in total length about 75 to 80 mm., is in this respect smaller than *M. winnemana,* but much larger in breadth, cranial and other characters. The smallest existing mammal is probably a minute *Crocidura* of the subgenus *Pachyura* from Madagascar.

The Insectivora, essentially an archaic and primitive group, reached its highest development in point of numerous and diverse adaptations in the Middle Eocene, from which there has been a gradual and steady decline. *Sorex* is known from the Middle Oligocene, *Talpa,* the mole from the Upper Oligocene and *Erinaceus,* the hedgehog from the Lower Miocene. These are some of the oldest of existing genera of mammals. The Malayan genus *Gymnura,* an Erinaceid, was said by Huxley[2] to possess the most generalized structure of all placental mammals. The persistence of the group is without doubt due in a large part to the small size and relative inconspicuousness of its members.

[31] Chappellier, A., "Recherches sur des hybrides végétaux (Traduction française). *Bulletin Scientifique de la France et de la Belgique,* Vol. 41, 1907, pp. 371–420.

[32] Baur, E., "Einführung in die experimentelle Vererbungslehre," Berlin, 1911.

[33] Haecker, V., "Allgemeine Vererbungslehre," Braunschweig, 1911.

[34] Goldschmidt, R., "Einführung in die Vererbungswissenschaft," Leipzig, 1911.

[1] *Proc. Biol. Soc. Wash.,* Vol. 23, p. 101, 1910.

[2] *Proc. Zool. Soc. London,* p. 657, 1880.

The separation of Madagascar from Africa has permitted the continuance of the relatively large Centetidæ, the tenrecs, of which *Ericulus, Centetes* and *Hemicentetes* have developed a spiny coat and *Limnogale* has become aquatic. Similarly, the rare and interesting Zalambdodont, *Solenodon,* has been able to continue an existence by isolation in Cuba and Hayti. Even thus isolated, *Solenodon,* judging from its extreme rarity, barely maintains a foothold. The aberrant Tupaiidæ, or Oriental tree shrews, are, as indicated by their name, arboreal and the African Macroscelididæ, or elephant shrews seek refuge by leaping and by skulking. The South African Chrysochloridæ, or golden moles, and the familiar Talpidæ are subterranean. A subterranean habitat implies a restricted stature. *Erinaceus,* the well-known hedgehog, and the African *Potamogale,* the only relatively large non-insular insectivores, are well protected, the former by its spiny coat and the latter by its aquatic habits. The Soricidæ containing the smallest members of the order are largely nocturnal. During the long stretch of time since the Eocene culmination of the group and the gradual evolution of more modern mammalia, the Insectivora have become extinct with the exception of those especially protected, insular, subterranean or of insignificant size. Smallness here seems an attendant trait of archaism. The earliest American mammals, the Triassic Protodonts, *Dromatherium* and *Microconodon* and among recent mammals certain Murine rodents closely simulate this diminutive stature.

The massive Rorqual whale, *Balænoptera sibbaldii* Gray, of the North Atlantic, sometimes reaching a length of eighty-five feet, is the bulkiest vertebrate which has ever existed. The Cetacea are likewise a primitive and probably degenerate group. Other aquatic mammals, such as the Sirenia, Pinnipedia, etc., similarly reach immense proportions, due, very likely, to the lack of a compensatory element in the environment. The tallness of the giraffe, which is an adaptation to arboreal grazing, produced by an elongation of the cervical vertebræ, coordinated of course with limb structure, has independently arisen in at least one other family. The giraffe-camels of the genera *Oxydactylus* and *Alticamelus,* respectively, of the American Oligocene and Miocene, parallel the existing giraffes.

The smallest known bird is *Calypte helenæ* (Gundlach) of

Cuba, measuring in total length but 57 mm.[3] Several other humming birds, notably *Mellisuga minima* (65 mm.) of Jamaica, are but slightly larger. The Trochilidæ comprise about 600 known forms, most of which are excessively small. *Patagona gigas* of the higher Andes, the largest of the group measures about 215 mm. in length. The size of the members of this family is an adaptation to the physical requirements of a highly active life, which is essentially that of securing food while hovering before blossoms. The Nectariniidæ or sun-birds of the Ethiopian and Indian Regions parallel the Trochilidæ in size and brilliancy. The Dicæidæ or "Flower-peckers" of India and Australia, and the Troglodytidæ and Regulidæ, wrens and kinglets of this country, likewise contain very small forms.

Sphærodactylus sputator Gray (45 mm. plus), occurring in the West Indies, is one of the very smallest of American reptiles.[4] *S. notatus* Baird (50 mm.) of Florida and the West Indies and a number of other West Indian lizards are hardly larger. The largest of existing lizards are members of the Varanidæ of Africa, Asia and Australia, the Malayan *Varanus salvator* (Gray) reaches a length of eight feet. Of the adaptive radiations which the Lacertilians have undergone, that branch containing the Amphisbænidæ, minute, legless, burrowing forms of tropical America and Africa, is of peculiar interest. This family presents a most remarkable illustration of the principle of heterology of Cope, of parallelism and convergence of other authors. Through the dominance of essentially similar environmental factors, certain species have come to resemble the earthworm with such fidelity, that the very chickens which follow the plow are said to seem unable to differentiate and indiscriminately pick them up.[5]

These remarks may apply equally well to the Typhlopidæ and Glauconiidæ, still widely distributed in tropical countries, archaic and degenerate, sightless, burrowing snakes, relicts of a once cosmopolitan assemblage, which contain the very smallest known Ophidians. *Helminthophis petersi* Boulenger (110 mm.) of Ecuador, *Typhlops anchietæ* Bocage (119 mm.) of Angola, Africa, *Glauconia dissimilis* (Bocage) (104 mm.) of the White Nile and *Glauconia bilineata* (Schlegel) (110 mm.) of the West

[3] Ridgway, *Rep. U. S. Nat. Mus.*, 1890, p. 295 (1892).

[4] Boulenger, "Cat. Lizards Brit. Mus.," 2d ed., Vol. 1, p. 219, 1885.

[5] Eigenmann, *Biol. Bull.*, Vol. 8, no. 2, p. 60, 1905.

Indies, are some of the smallest species. The largest existing reptile is the Ganges crocodile, *Gavialis gangeticus* (Gmelin) of northern India, which is said to attain a length of thirty feet or more. This, however, is insignificant in comparison with that attained by the sauropodous dinosaurs of the Mesozoic. The American genera *Atlantosaurus*, *Brontosaurus*, *Camarasaurus* and *Diplodocus* were immense creatures. *Atlantosaurus immanis* Marsh of the Wyoming Upper Jurassic, supposedly terrestrial from mechanical considerations, is one of the largest land vertebrates which has ever existed, probably upwards of one hundred feet in length. The uncompensated extravagance of energy in the maintenance of such immensity, coupled with the small and primitive brain, were without doubt to a great extent factors in the extinction of these gigantic vertebrates. These animals are without living descendants.

The familiar "spring peeper," *Hyla pickeringii* (Storer), about 20–28 mm., of eastern North America is the smallest American *Hyla* and thus one of our smallest batrachians. The Hylidæ, comprising about 150 species, have a practically cosmopolitan distribution with the exception of Africa and the Malay Archipelago. Essentially arboreal, in the dense, steaming tropical forests of South America they attain the highest diversity of generic and specific types. *H. pickeringii* does not ordinarily ascend into the trees until early in autumn. A number of true frogs are as small or smaller, thus *Arthroleptis seychellensis* Boettger of the Seychelles, interesting from its habit of carrying its eight or nine tadpoles affixed by their ventral surfaces to its back, is but about 20 mm. in length of head and body. The smallest salamander of the eastern United States is the red-back, *Plethodon cinereus erythronotus* Green, an elongate form of about 75 mm. The largest salamander and the largest existing batrachian is *Megalobatrachus japonicus* (Temminck), the giant salamander of Japan, which reaches a length of over five feet. At no time have the Batrachia been the dominant type of vertebrate life, either in size or variety of forms.

It is among the fishes that we find the smallest known vertebrates. Thus, *Mistichthys luzonensis* H. M. Smith,[6] an extraordinarily minute goby from Lake Buhi, Luzon, P. I., is accorded this distinction. The average length of this species is 12.9 mm. The average for egg-bearing females which exceeds the average

[6] *Science*, N. S., Vol. 15, p. 30, Jan. 3, 1902.

for males by one millimeter is 13.5 mm., the maximum is 15 mm., and the minimum is under 12 mm. This species is said to be a food fish of considerable importance as it is seined by the natives in large quantities, dried in cakes or mixed with spices, and is eagerly sought for. The great majority of the six hundred known species of Gobiidæ are less than 75 mm. in length. *Philypnus dormitor* (Lacépède) of Central America and the West Indies, the largest of the family, reaches a length of 600 mm.

The Etheostominæ or darters contain some of the smallest spiny-rayed fishes. *Microperca punctulata* Putnam (25–38 mm.) of the Central States is next to *Elassoma evergladei* Jordan (20–33 mm.) a minute percoidean of our southeastern swamps, the smallest American spiny-rayed fish and a number of other darters are but slightly larger. *Heterandria formosa* Agassiz, a diminutive viviparous Pœciliid, occurring in swamps and ditches from South Carolina to Florida, was for a long while considered the least of American vertebrates. This species has an average length of 19 mm. for males and 25 mm. for females. *Acanthophaceius bifurcus* of the ponds and creeks of British Guiana, recently described by Eigenmann,[7] is still smaller; the average for both sexes is 21.5 mm. and the largest of 74 specimens is 29 mm. long. A number of pregnant females are but 20 mm. in total length and one of these, preserved in alcohol, in the Indiana University collections weighs but .076 gram. The weight of living specimens is probably somewhat greater. The exact measurements of this specimen (I. U. No. 11,765) are as follows: total length 20 mm., length to base of caudal 16 mm., depth 5 mm. and breadth or thickness 3 mm. The smallest male specimen here, one in full nuptial coloration, measures 19 mm. over all. In all probability, the smallest new world vertebrate is *Heterandria minor* Garman,[8] from Villa Bella, Brazil. The average total length of this species is 18 mm. for males and 20.5 mm. for females. Females of but 19 mm. "contain fully developed embryos." With this may be contrasted the bulk of *Arapaima gigas* (Cuvier) of neighboring streams of Brazil and Guiana, said to reach a length of fifteen feet and to be the largest strictly fresh-water fish known.

[7] *Annals Carnegie Museum*, Vol. 6, p. 52, 1909.

[8] *Memoirs Mus. Comp. Zool.*, Vol. 19, no. 1, p. 92, 1895.

The Pœciliidæ or killifishes, found in most warm portions of the globe, comprise about two hundred very small species, the largest *Fundulus, Anableps,* etc., seldom exceed 300 mm. In the inviting streams of Central America where the majority of species occur, adaptive radiation, as in every large family of fishes, has taken place, from the central type *Fundulus,* resulting in the depressed catfish-like *Rivulus,* the beaked garpike-like *Belonesox,* the sunfish-like *Goodea,* the carp-like *Cyprinodon,* etc.

The origin of these small forms may probably be explained by the selective migration and the successive adaptation of the species occupying the deeper reaches of the streams. The Pœciliidæ usually feed at the surface and thus may tend to disseminate throughout the full extent of the shallower waters. *Acanthophacelus* has evidently been derived from *Pœcilia,* from which it differs chiefly in the acquirement of two rows of retrorse hooklets on the modified anal fin of the male, while *Heterandria* is of a different type with conical, carnivorous dentition and shortened alimentary tract. Further exploration may reveal still smaller species of these interesting little fishes, which are likely, however, to pass unobserved by all but the trained naturalist.

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